PUTTING RESEARCH TO WORK BRIEF

A Bridge Inspector's Guide to Non-Destructive Tests

The Wisconsin Department of Transportation requires routine inspection every two years of the thousands of bridges on the state highway system; federal requirements add underwater member inspection every five years. Additional in-depth inspections may follow the identification of defects during a routine inspection, or may occur after a traffic accident that causes damage.

Routine bridge inspections rely heavily on visual assessments. While some non-destructive techniques—such as listening for hollow spots by dragging chains across decks or tapping girders with hammers—are widely used, WisDOT has not fully explored the range of sophisticated non-destructive evaluation techniques available.

What's the Problem?

Non-destructive evaluation can provide information that may be impossible to deduce from visual inspection alone. Integrating both methods is key to a complete bridge condition assessment—data that directly informs the decision to repair or replace a bridge.

An array of deterioration mechanisms can afflict bridges, singly or in combination. Though many non-destructive testing methods exist, WisDOT lacks a guide for matching visual indications of deterioration with non-destructive evaluation techniques. The best NDE technique for each circumstance depends on bridge structure, inspector skill, and available equipment and resources.

Research Objectives and Methodology

This study aimed to develop guidelines for integrating visual and non-destructive evaluation methods for bridge inspection, a critical first step toward revised and improved bridge condition assessment and management processes.

Through an extensive literature review, researchers catalogued dozens of deterioration mechanisms and their visible manifestations in bridges, and identified non-destructive testing techniques suited to each type of deterioration. Since 95% of Wisconsin's bridges are concrete—reinforced, prestressed or post-tensioned—or steel, researchers limited their study to these two bridge types.

Results

Investigators identified a variety of types of deterioration in bridges, including several kinds of cracking in concrete and corrosion in steel. They then matched each problem to NDE methods capable of determining the presence and extent of the damage, and outlined the applicability, advantages and disadvantages of each method. Detailed results included:

Concrete—Decks and Superstructure. Investigators identified 19 typical problems and visual indicators of distress in concrete bridge decks and superstructures, linking them to 20 deterioration mechanisms. Researchers categorized problems as early age deterioration (such as shrinkage cracking and settlement cracking over rebar), long-term deterioration (including pattern cracking due to alkali-silica reactions, and delamination from rebar corrosion), and in-service deterioration (such as midspan spalling due to overloading, and cracking and corrosion from defective expansion joints). The study cites 30 non-destructive evaluation methods, including ground-penetrating radar and infrared thermography for locating delaminations and voids, impact echo techniques for determining the extent and depth of voids and locating embedded metallic materials, and radiography for locating voids and major corrosion of reinforcing steel.

Steel—Decks and Superstructure. Researchers described five typical problems and visual indicators in steel bridge decks and superstructures, linking them to 20 deterioration mechanisms. Fatigue can lead to cracking and sudden failure; corrosion can cause section loss and fatigue; brittle failure can

Investigator

"Our goal was to document the most common problems in bridges and then match them to the most appropriate non-destructive evaluation techniques."

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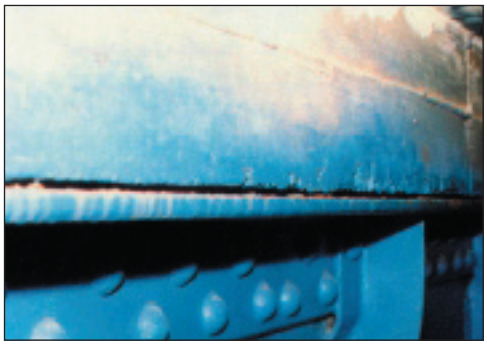

Crevice corrosion in layers of steel can bend plates, or strike between concrete and steel. Surface corrosion may be visible in routine bridge inspections, but non-destructive ultrasonic testing can yield information on the extent of unseen damage (Fig. 38 and 39, page 32 of the final report).

strike intersecting welds; fire damage can reduce component strength; and impact can lower load-carrying capacity or induce failure. The study cites 12 evaluation methods, such as magnetic particle testing for locating small cracks near the surface, dye penetrant testing to determine the extent of surface cracking, and radiographic testing of internal and subsurface steel condition.

The study also describes problems and deterioration mechanisms common to substructure members, bearings, and movable bridges, and identifies NDE methods appropriate to these structures and components.

For easy reference, Appendices A and B of the final report provide tables of problems and solutions, linking visual symptoms to underlying causes and appropriate testing methods. Appendix C provides detailed descriptions of over 70 NDE techniques.

Implementation and Benefits

This guide will assist inspectors in identifying the causes of bridge deterioration, and direct them to appropriate testing options. Some simple non-destructive techniques, such as hammer sounding, rebound hammer testing, dye penetration, and magnetic particle testing, can be easily integrated into visual inspections. The results of these integrated inspections will improve bridge data files, and will yield more technically based recommendations for further inspection and maintenance, and more accurate estimations of remaining service life.

Further Research

This research provides a broad overview of many NDE methods. Researchers recommend that WisDOT study individual methods in greater depth to identify the most appropriate techniques for the types of structures common in Wisconsin. Detailed guidelines should be developed to address planning, mobilization, safety considerations, and integration of NDE data into the bridge management system. WisDOT should also develop an NDE training program for inspectors.

Project Manager

"This project identified non-destructive methods for evaluating structures and making decisions to repair or replace. It's a very good resource for the field inspectors."

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